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ABSTRACT

This paper describes a multivariate model of early infant competence formulated from variables representing infant-environment transaction including: birthweight, habituation index, personality ratings of infant social orientation and task orientation, ratings of maternal responsiveness to infant distress and social signals, and observational measures of latency of maternal response to infant distress and vocal signals taken in the home. The Bayley Scales of Mental and Motor Development were administered when the infants were 2 1/2 and 6 months old, and multiple linear regression analysis was performed on infant and maternal variables. The sample consisted of 51 first born infants of normal birthweight and free of significant birth defects. Results of this study support transactional developmental perspective where both infant and environmental characteristics are predictors of competence. (Author/MS)

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Multivariate Model of Infant Competence

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This report concerns a portion of a two year longitudinal study of infant competence carried out at the Peabody Infant Laboratory. This aspect of the research on infant competence includes measures when the infants were 2½ and 6 months old. A model of early infant competence was formulated from variables representing a transactional perspective reflecting a progression from initial status of the neonate to more distal measures of maternal responsiveness within the caretaking environment. The variables were also selected in nearly equal number to reflect an organism-environment transaction between initial levels of physical and visual perceptual development, infant personality characteristics, and maternal measures that could be construed as measures of contingent environmental response to infant behaviors. These combined measures were used as indicators of a system of transactions that was validated by relating them to independent measures of developing competence during the same time period and across time. The Developmental and Motor Indexes of the Bayley Scales of Infant Development were selected as the independent criteria. These scales were chosen because they present to the infant a variety of age appropriate tasks in a novel setting. Clarke-Stewart (1973) has described these scales as "measuring a comprehensive range of specific competencies" (p. 71).

The following variables were included in the transactional model:

(1) Birth weight(B_{wt}): The infant's weight was measured in ounces at the time of hospital delivery by attending medical personnel.

(2) Habituation Index(HI): The index for habituation to a visual stimuli included a measure of the magnitude of response decrement in relation to number of trials to criterion. The formula gives advantage to infants who process or encode information in the fewest possible trials.

(3) Personality Measures: The infants were rated at 2½ and 6 months on all items of the Bayley Infant Behavioral Record. These scales were administered in the same laboratory setting for all subjects. Selected items were chosen from the Behavioral Rating Scale which have face validity as measures of the infant's "Social Orientation(SO)" and "Task Orientation(TO)" as observed in the examination setting. These subscales demonstrated internal reliability.

(4) Observational Maternal Measures: Maternal measures which included a total of 90 minutes of observational data collected by a single observer in the child's home. Mother-infant interactions were recorded on a Datamyte Recorder. This recorder allowed the observer to record continuously any events precoded into numerical codes on a cassette audio tape recorder. The time of each event was entered automatically by an internal clock, thus, not only order of events, but also latencies and durations were recorded. Two measures of maternal latency were extracted as they index a dimension of maternal contingent responsiveness

to infant behavior. The two measures are: Maternal latency in response to infant's distress vocalization(OMLD) and Maternal latency in response to infant's social/vocal behavior(OMLV). The latency of maternal responses were recorded in 10 second time segments following the onset of infant behavior.

(5) Rated Maternal Latency(MR): Another set of maternal behaviors recorded were rated maternal latencies. Following the 90 minute observational period the observer made ratings of various environmental parameters. Two latency ratings were made: maternal latency to distress, and responsiveness to infant social behaviors. These measures were collapsed into one measure: maternal responsiveness to infant behaviors. This rated measure was included in that it may more adequately reflect qualitative differences in maternal behavior than the measures of latency of response measured in seconds.

Subjects

The subjects in the sample were firstborn, full-term singleton infants with birth weights between 5.5 and 9.5 pounds who were free of significant health complications as indicated on the birth record; parents of these infants were married, with each parent over 20 years of age and at least a high school graduate. Fifty-four Ss were included in the

initial phase of the study. Two families moved and one infant died prior to the 6 month measure--leaving a sample of 51 infants: 26 females and 25 males.

RESULTS

The first level of multiple linear regression analysis was performed on infant and maternal predictor variables at 2½ and 6 months to predict infant scores on the Bayley Developmental Index(DI) and the Bayley Motor Index(MI) (motor development). The results of these analyses are reported in Table I for the criterion variables at the two ages. This level of analysis indicated that, indeed, a significant proportion of the variance in both mental and motor development was accounted for by the combination of infant and maternal variables at both ages. At 2½ months over 50% of the variance was accounted for by the group of variables predicting the DI and MI. At 6 months the percentage of variance accounted for declined to 42% for DI and 27% for MI.

Multiple linear regression was performed testing each variable against the full model which consisted of all the variables used to predict mental and motor development separately at 2½ and 6 months. Table 2 contains the results of these analyses for 2½ months.

Summary of Regression Analysis at 2½ Months

At 2½ months, while Bwt, SO and TO are significant correlates of the full DI model (containing all predictor variables), TO alone is the most useful predictor of DI, while Bwt is the next most useful predictor. For the MI models, TO is also the most useful predictor followed by Bwt,

and OMLD. The relationship between MI and OMLD indicates that longer maternal latency to respond to infant distress signals is related to high infant motor development.

Summary of Regression Analysis at 6 Months

At 6 months,(table 3)while the set of predictor variables account for less than 50% of the variance in DI and MI, TO continues to be the best single predictor of both variables. SO contributed 22% of the variance to the DI model while HI contributed 10% of the variance to both models. A maternal variable, MR, and SO each contribute 7% of the variance to the MI model. The Rated Maternal latency variable is negatively correlated with the MI indicating the relationship between low rated maternal responsiveness and high infant motor development.

The findings at 6 months are analogous to the 2½ month findings, however, HI replaces Bwt in predicting MI at 6 months and low rated maternal responsiveness(MR) at 6 months replaced another long latency maternal measure OMLD in predicting the MI.

Maternal Variables

Because OMLD is a significant predictor variable of MI at 2½ months, multiple linear regression was performed on infant and maternal variable to predict OMLD. The infant predictor variable included in this analysis were the Bwt, HI, DI, and MI of the infant. Maternal variables were also used to predict maternal response to distress and included: OMLV, MRS, and MRD. This combination of variables was selected to determine

if OMLD could be predicted from infant or maternal characteristics, e.g.: does the mother's own behavior in response to other infant behaviors predict her response to distress, or do infant characteristics serve as predictors of this maternal behavior? The results of this analysis indicate that a significant proportion of the variance in OMLD can be accounted for by using these predictor variables ($R = .59$, $R^2 = .35$, $F = 3.327$, $df = 7, 43$ $p < .01$). Each variable was extracted successively, beginning with infant variables, and the remaining predictor variables formed the restricted model that was tested against the full model containing all predictor variables.

The subset of variables that did not differ significantly from the full model contained the infant's MI in combination with all other maternal variables. Further extraction of maternal variables from the restricted model produces models that differ significantly from the full model indicating that the infant's MI is the best single predictor of OMLD. In this analysis, MI and OMLD are inversely related ($r = .372$, $p < .01$) which indicates that long maternal latency to infant distress signals and high motor competence are significantly related. The second most significant predictor of OMLD is the infant's birth weight. The model which includes Bwt and all other predictor variables accounts for 59% of the variance in OMLD, while the model that excludes Bwt but includes all other predictor variables accounts for 50% of the variance in OMLD. The correlation between Bwt and OMLD is not signficant ($r = .086$), however, Bwt correlates with the signficant predictor variable MI ($r = .488$, $p < .01$).

Prediction Across Age

Prediction across time included multiple linear regression analysis on the 2½ month predictor variables to predict the 6 month criterion variables. The proportion of the variance accounted for by the 2½ month model was not statistically significant ($p<.05$). Less than 20% of the variance was accounted for in the 6 month DI and MI models.

Although the selected 2½ months variables failed to predict a significant proportion of the variance at 6 months, the infant's own DI and MI at 2½ months were significantly related at 6 months ($R(DI)= .378$, $p<.01$; $R(MI)= .326$, $p<.05$).

Patterns of Correlations by Sex Across Age

To explore the possibility that sex differences may be present in patterns of correlations across age, Pearson Product Moment Correlations were calculated separately for males and females.

Patterns of Correlates of Infant Competence

The findings regarding different patterns and/or timing sequences for males and females can be briefly summarized:

(1) The 2½ month motor index for all subjects in the sample is related to mental and motor competence at 6 months. However, when these correlations are calculated by sex, a statistically significant relationship exists for females ($r = .61$, $p<.01$, DI; $r = .40$, $p<.05$, MI) and not for males.

(2) Birth weight is a significant correlate of mental and motor competence at 2½ months for all subjects, but continues as a significant correlate of mental competence at 6 months only for males ($r = .42$, $p < .05$).

(3) The habituation index fails to correlate with other infant characteristics for all subjects at 2½ months, although at 6 months, it is a significant correlate for all subjects of mental ($r = .32$, $p < .01$) and motor ($r = .32$, $p < .01$) competence. The Habituation index is stable across time for males but not for females.

(4) Social orientation at 2½ months is significantly related to task orientation at 6 months ($r = .40$, $p < .01$), however, when analyzed by sex, the relationship for females ($r = .43$, $p < .05$) between these variables is significant but not for males.

(5) There was no consistency in <u>observed</u> latencies of maternal responses to infant vocal and distress behaviors within or across time.

(6) <u>Rated</u> maternal responsiveness to infant distress and social behaviors are correlated across time periods for all subjects, however, when these measures are analyzed separately by sex, this relationship remains significant for females while only maternal response to distress is significantly related across time for males.

(7) The 2½ month ratings of maternal response to infant distress and social behavior ($r = .50$, $p < .01$) are significantly related to each other for all subjects, but these same ratings are not significantly related at 6 months. Females follow the same pattern found for all subjects while rated maternal responses to infant distress and social behaviors continue to be significantly related at 6 months for males ($r = .47$, $p < .05$).

The patterns of correlations for males and females indicate that the paths to competence may differ, but more importantly, the time at which patterns emerge is different for the males and females in this sample.

The general pattern of relationships of variables with mental and motor competence changes over time for males and females in terms of their relationship to maturational characteristics and characteristics of the infant's environment. While the mental and motor competence of males appears to be influenced at least through 6 months by initial physical status, this relationship for females is noted only at 2½ months. On the other hand, maternal characteristics are related to female infant competencies at 2½ months, a relationship that appears at 6 months for males. One finding that should be noted, however, is the initial influence on mental and motor competency of the infant's status at birth as indicated by birth weight. It appears that the infant who was able to profit from an enriched prenatal environment does indeed enter the world with some maturational advantages, even within this sample of normal birth weight infants. The change in the birth weight/mental and motor competency

relationship for females between 2½ and 6 months may signal an earlier decline in the influence of "maturational factors" for female than for male infants in this sample. This decline in maturational influence is associated for females with the earlier rise of the influence of maternal behaviors on female infant competence. Males do not show evidence of this pattern change until 6 months, when competence measures become linked to maternal behaviors. When male competencies become significantly related to maternal behaviors, the patterns differ somewhat from those established by females. Therefore, it is difficult to project from these data whether patterns for males emerge later than the same patterns for females, or if they are truly different. Nevertheless it should be noted that males do tend to lag behind females in the patterns of relationships of competency variables with environmental variables.

Conclusions

The acquisition of early infant competence does indeed appear to involve the interplay of maturational/physical, personality, and environmental events, and therefore, cannot be assumed to come from the organism alone or from the environment alone. In early infancy, however, the infant's own characteristics appear to weigh very heavily in his/her transactions with the environment. While this relationship appears to lessen over time, another sampling of infant and maternal behaviors at a later time would be necessary to validate these emerging patterns. Female infants appear to "overcome" initial maturational influences and

become adapted to the environment earlier than do males, however, this does not exclude the possibility of differential attitudes and expectations and adaptive behaviors displayed by mothers of males and females. It appears that mothers of female infants differentiate their own pattern of responses to infant behaviors earlier than do the mothers of male infants. However, whether this is because the mothers of males and females have different expectations for their infants from the outset or because the female infants are more effective "teachers" of maternal behaviors remains to be answered.

Table 1

All Infant and Maternal Variables Predicting MI and DI against Zero

Criterion Variable	Age (months)	R	R^2	F	P
DI	2½	.75	.56	7.733	.01
MI	2½	.77	.60	7.94	.01
DI	6	.64	.42	4.364	.01
MI	6	.52	.27	2.22	.05

df = 7, 43

Table 2

Individual Predictor Variables Tested Against the Full Model at 2½ Months

Predictor Variable	Criterion Variable: DI			MI		
	R	R^2	F ratio	R	R^2	F ratio
Bwt	.28*	.077	7.876**	.45**	.20	7.028**
HI	.02	.00	9.123**	.17	.03	10.08**
SO	.406**	.165	6.434**	.38*	.15	7.995**
TO	.69**	.48	1.358	.54**	.29	5.462**
MR	.045	.00	9.090**	.05	.00	10.548*
OMLD	.18	.03	8.621**	.372**	.14	8.127*
OMLV	.115	.01	8.913**	.077	.00	10.481*

* = p .05; ** = p .01; df = 6, 43

Table 3

Individual Predictor Variables Tested
Against the Full Model at 6 Months

Predictor Variable	DI R	DI R^2	DI F ratio	MI R	MI R^2	MI F ratio
Bwt	.18	.03	4.674**	.02	.00	2.59*
HI	.32*	.10	3.85**	.32*	.10	1.619
SO	.47*	.22	2.37*	.25	.07	1.96
TO	.48**	.23	2.26	.35*	.12	1.42
MR	.20	.04	4.597**	-.27*	.07	1.869
OMLD	.18	.03	4.698**	.20	.04	2.219
LMLV	.19	.04	4.638**	.16	.03	2.349*

** p = .01
* p = .05

df = 6, 43